Webinars
Series of scientific webinars that provide a forum for discourse on scientific issues.
- Live and On-Demand
- Case Conferences
- Journal Clubs
- Grand Rounds
- CE Available

Online Courses
Evidence-based online courses on a variety of children's environmental health topics.
- Interactive and Self-Paced
- CE Available

Resource Catalog
Fact sheets, journal publications, reports, and other resources for parents, community members, patients and healthcare professionals.
- Topics included: Air Quality, Pesticides, Natural Disasters, BPA, Mold, Lead, Mercury
Fukushima and Chernobyl: Near and Long-term Effects On Children

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Southwest Center for Pediatric Environmental Health
Texas Tech University Health Sciences Center– El Paso
El Paso, TX, USA
The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing partial funding to ATSDR under Inter-Agency Agreement number DW-75-95877701. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

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The speaker has made liberal use of the training materials and illustrations of the US Centers for Disease Control and Prevention and gratefully acknowledges their contributions.

http://emergency.cdc.gov/radiation
• Current status of nuclear power generation
• Power plant types, radiation basics, isotopes of concern
• Chernobyl, 1986 and its effects on children
• Fukushima, 2011 and children, now and in the future
• Radiological emergency resources
Current Status Of Nuclear Power Generation
Distribution of nuclear power plants

Status of commercial nuclear power
- Building first plant
- Building new plants
- Considering first plant
- Considering new plants
- Stable
- Considering decommissioning
- All plants decommissioned
- No commercial reactors
- Nuclear-free area

"Nuclear power stations". Licensed under CC BY-SA 3.0 via Wikimedia Commons – 2009
https://commons.wikimedia.org/wiki/File:Nuclear_power_stations.png#/media/File:Nuclear_power_stations.png
According to the International Atomic Energy Agency (IAEA), there are:

- 446 nuclear power reactors in operation, worldwide
- 2 nuclear power reactors in long-term shutdown
- 63 nuclear power reactors under construction

The five newest connections to the grid include:

- 3 in China
- 1 in the Republic of Korea
- 1 in the US

http://www.iaea.org/pris/Home.aspx
Highlights of America's New Reactor

- Watts Bar-2: Tennessee Valley Authority
  - 1165 MWe net capacity
  - Construction start date: 09/01/1973
  - Construction suspension date: 09/17/1985
  - Construction restart date: 10/15/2007
  - First criticality date: 05/23/2016
  - First grid connection: 06/03/2016
  - Initial cost estimate: $400 million
  - Total cost estimate: $6.1 billion

http://latimes.com
Highlights of America's Largest Solar Thermal Power Station

- Ivanpah Solar Power Facility: PG&E
  - 392 MWe net capacity
  - Construction start date: 10/27/2010
  - Construction suspension date: NA
  - Construction restart date: NA
  - First sync testing date: 09/2013
  - First grid connection: 02/13/2014
  - Initial cost estimate: ND
  - Total cost estimate: $2.2 billion

Photo credit: Craig Dietrich - Flickr: Ivanpah Solar Power Facility
en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility#Economic_impact
<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>INES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Japan</td>
<td>7</td>
</tr>
<tr>
<td>1986</td>
<td>Ukraine</td>
<td>7</td>
</tr>
<tr>
<td>1957</td>
<td>Russia</td>
<td>6</td>
</tr>
<tr>
<td>1979</td>
<td>US</td>
<td>5</td>
</tr>
<tr>
<td>1957</td>
<td>UK</td>
<td>5</td>
</tr>
<tr>
<td>1952</td>
<td>Canada</td>
<td>5</td>
</tr>
<tr>
<td>2006</td>
<td>Belgium</td>
<td>4</td>
</tr>
<tr>
<td>1999</td>
<td>Japan</td>
<td>4</td>
</tr>
<tr>
<td>1993</td>
<td>Russia</td>
<td>4</td>
</tr>
<tr>
<td>1983</td>
<td>Argentina</td>
<td>4</td>
</tr>
<tr>
<td>1980</td>
<td>France</td>
<td>4</td>
</tr>
<tr>
<td>1977</td>
<td>Czechoslovakia</td>
<td>4</td>
</tr>
</tbody>
</table>

**International Nuclear Event Scale**

- **7 MAJOR ACCIDENT**: Major release; widespread health and environmental effects
- **6 SERIOUS ACCIDENT**: Significant release; likely to require full implementation of planned countermeasures
- **5 ACCIDENT WITH OFF-SITE RISK**: Limited release; likely to require partial implementation of planned countermeasures
- **4 ACCIDENT WITHOUT SIGNIFICANT OFF-SITE RISK**: Minor release; public exposure of the order of prescribed limits

Illustration by Silver Spoon (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

Data from [www.theguardian.com](http://www.theguardian.com)
Power plant types
Radiation basics
Isotopes of concern
Pressurized Water Reactor

http://www.nrc.gov/images/pwrsm.jpg
Boiling Water Reactor

Figure 2-1 - Diagram of general operation of a BWR

1. Reactor Pressure Vessel (RPV)
2. Nuclear Fuel Rod
3. Control Rod
4. Circulating Pumps
5. Control Rod Motors
6. Steam
7. Feedwater
8. High Pressure Turbine
9. Low Pressure Turbine
10. Generator
11. Exciter
12. Condenser
13. Cold Water
14. Pre-heater
15. Feedwater Pump
16. Cold Water Pump
17. Concrete containment (or container)
18. Connection to electric grid
Spectrum of Electromagnetic Energy

IONIZING RADIATION

RADIO  MICROWAVE  INFRARED  VISIBLE  ULTRAVIOLET  X-RAY  GAMMA RAY

ELECTROMAGNETIC SPECTRUM

http://emergency.cdc.gov/radiation/
Radioactive Decay

http://emergency.cdc.gov/radiation/
Radioactive Physical Half-life

$^{99m}$Tc: 6h

$^{238}$U: 4.5 billion years
Amount of Radioactivity

- **BECQUEREL (Bq)**
  - International unit
  - 1 radioactive decay/sec

- **CURIE (Ci)**
  - U.S. unit
  - Activity in 1 gram radium

Average banana has 12 Bq radioactivity as K-40

http://emergency.cdc.gov/radiation/
Exposure Rate

<table>
<thead>
<tr>
<th>International (INT’L)</th>
<th>United States (U.S.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray/hour (Gy/h)</td>
<td>Roentgen/hour (R/h)</td>
</tr>
<tr>
<td>Sievert/hour (Sv/h)</td>
<td>rem/hour (rem/h)</td>
</tr>
<tr>
<td>nGy/h</td>
<td>uR/h</td>
</tr>
<tr>
<td>uSv/h</td>
<td>mrem/h</td>
</tr>
</tbody>
</table>
For our purposes,

1 Sievert (Sv) ~ 1 Gray (Gy)
# Typical Doses in Millisieverts (mSv)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NY to London by Air</strong></td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Chest X-Ray</strong></td>
<td>0.1</td>
</tr>
<tr>
<td><strong>CT Scan (Abdomen)</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Natural Background (Annual)</strong></td>
<td>3</td>
</tr>
</tbody>
</table>

*Source: [CDC](http://emergency.cdc.gov/radiation/)*
EXTERNAL CONTAMINATION

External contamination occurs when radioactive material comes into contact with a person's skin, hair, or clothing.

- RADIOACTIVE MATERIAL
- IN THE AIR
- SOLID
- LIQUID

INTERNAL CONTAMINATION

Internal contamination can occur when radioactive material is swallowed or breathed in.

Internal contamination can also occur when radioactive material enters the body through an open wound.

Different radioactive materials can accumulate in different body organs.

RADIATION EXPOSURE

Another word for radiation exposure is irradiation.

Radioactive materials give off a form of energy that travels in waves or particles.

When a person has an x-ray, he or she is exposed to radiation but is not contaminated.

When a person is exposed to certain types of radiation, the energy may penetrate the body.

A person exposed to radiation is not necessarily contaminated with radioactive material.

For a person to be contaminated, radioactive material must be on or inside of his or her body.

http://emergency.cdc.gov/radiation
Exposure from a Radioactive Plume

External exposure occurs by gamma-emitting radionuclides, such as cesium-137 and iodine-131.

Internal exposure occurs by inhalation of radioactive gas or aerosols. Radioactive iodine tends to concentrate in the thyroid.

Once incorporated, the residence time in the body depends on the radioactive half-life of the radionuclide and how fast it is eliminated by natural bodily functions.
Continuing Exposure to Radioactivity

External exposure from gamma emitting radionuclides deposited on surfaces continues.

Internal contamination may occur through contaminated foodstuffs harvested in these areas.

Internal exposure may also occur from inadvertent ingestion of radioactive particles left on surfaces, including the soil. Young children are particularly at risk.

ISRN.fr report IRSN/DG/2012-003
Isotopes of Concern

Target organs:

I: Thyroid
- I-131 – $T_{1/2} = 8\text{d}$
- I-132 – $T_{1/2} = 2.3\text{h}$
- Te-132 – $T_{1/2} = 3.2\text{d}$

Cs: Follows potassium
- Cs-137 – $T_{1/2} = 30\text{y}$
- Cs-134 – $T_{1/2} = 2\text{y}$

All emit $\beta$ and $\gamma$ radiation
### Range of Radiation Doses

**COMPARING RADIATION DOSES**

**IN MILLISIEVERTS (mSv)**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York to London by air</td>
<td>0.05</td>
</tr>
<tr>
<td>Chest X-ray</td>
<td>0.1</td>
</tr>
<tr>
<td>Natural background (annual)</td>
<td>3</td>
</tr>
<tr>
<td>CT scan (abdomen)</td>
<td>10</td>
</tr>
<tr>
<td>Occupational limit (annual)</td>
<td>50</td>
</tr>
<tr>
<td>50% survival dose</td>
<td>4,000</td>
</tr>
</tbody>
</table>
Why is Radiation of Greater Risk to Children?

- Relatively larger body surfaces
- More actively dividing cells
- Greater sensitivity of central nervous system
- Greater hand-to-mouth activity and more rapid respirations
  - ↑ Risk of internal contamination
- Thinner skin (controversial)
  - ↑ Risk of local radiation injury, ↑ β penetration
- Longer life span (↑ “opportunity” for cancer due to latency of cancer effects)

Bartenfeld 2014 Biosecur Bioterror 12, 201-207
Derraik 2014 PLoS One
Pregnancy

- Gestation <2 wks: Resistant to malformation, sensitive to lethal effects at doses much > 50mSv
- 3-8 wks: Not affected unless dose > 200 mSv
- 8-15 wks: CNS sensitive to doses > 300 mSv
- >20 wks: Fetus probably no more vulnerable than mother

- Offspring of atomic bomb survivors:
  - Cancer and noncancer mortality rates were no higher for subjects with exposed parents (5+ mSv or unknown dose) than for reference subjects (0-4 mSv), and mortality did not increase with increasing dose.

Chernobyl, 1986 and children
April 26, 1986– Meltdown of a boiling water reactor at Chernobyl

- Exposure of roughly 5 million people in Ukraine, Belarus, and the Russian Federation to substantial amounts of radioactive contamination (>35 kBq/m² of Cs-137)
- Among these, 400,000 were contaminated with >555 kBq/m² of Cs-137.
- 116,000 were evacuated in spring and summer 1986
- 220,000 additional people were relocated in subsequent years
Impact of Chernobyl

- Widespread release of radiation over Ukraine, Belarus and Russian Federation:
  - Estimated 50 immediate deaths, ~1000 emergency workers and plant personnel receiving the highest radiation doses
  - 600,000 registered as emergency workers ("liquidators")
  - By 2008, >6000 thyroid cancer cases diagnosed in children, largely attributed to radioactive iodine-contaminated milk
  - Since 1986, radiation levels have declined several hundredfold, rendering it "safe to return for settlement and economic activity." Chernobyl Exclusion Zone will be closed for decades

Chernobyl Forum 2003-2005 Chernobyl's legacy, 2nd ed.
Fushiki 2013 Brain Develop 35, 220-227
Whole body doses in the 50 km exclusion zone from 1986 to 2005 are estimated at 50 mSv; The estimation is 10 mSv for those living beyond the exclusion zone.

Leukemia, expected to occur in large numbers, fortunately has not.

However, a large increase in thyroid papillary carcinoma has been observed. Thyroid carcinoma was seen most often in children less than five years age at the time of exposure, indicating greater risk for the young.

Psychological effects appear to predominate in adults, according to some authors (Bromet, 2012).
Thyroid cancer risk in Belarus

- Study of 11,970 individuals 10-15y post-exposure, ≤ 18 years at time of Chernobyl incident who had iodine-131 thyroid dose based on individual thyroid activity measurements and dosimetric data questionnaires.

- For thyroid dose <5 Gy, the dose response was linear; at higher doses excess risk fell. Risk was greater for males and children less than five at time of exposure.

Zablotska 2011 Br J Cancer 104, 181-187
Thyroid Cancer Risk in Belarus

- Mean thyroid dose 0.56 Gray (~Sv)
- 53 patients with self-described thyroid cancers prior to the study excluded
- 87 new thyroid cancers (86 papillary, one follicular) underwent surgery. Nine cases had two or more separate thyroid cancers in different locations

**Figure 1** Distribution of thyroid doses in the cohort

Zablotska 2011 Br J Cancer 104, 181-187
Thyroid Cancer Risk in Belarus

Cohort of 87 thyroid cancer cases and 11,524 non-cases, screened 1996-2004

<table>
<thead>
<tr>
<th>Dose category, Gy*</th>
<th>Mean dose, Gy</th>
<th>Odds ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0.049</td>
<td>0.02</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0.15-0.29</td>
<td>0.22</td>
<td>2.09</td>
<td>0.76-5.75</td>
</tr>
<tr>
<td>0.45-0.64</td>
<td>0.54</td>
<td>3.27</td>
<td>1.13-9.46</td>
</tr>
<tr>
<td>1.25-2.24</td>
<td>0.90</td>
<td>5.27</td>
<td>1.80-15.46</td>
</tr>
<tr>
<td>5.00-32.80</td>
<td>8.84</td>
<td>6.75</td>
<td>1.26-36.22</td>
</tr>
</tbody>
</table>

*See article for complete data. Table condensed for convenience and readability.

**Figure 2**  Categorical odds ratios and fitted dose–response lines

Zablotska 2011 Br J Cancer 104, 181-187
Non-Thyroid Cancer in Belarus

- 15 year study of 12,000 individuals exposed to Chernobyl fallout at average age of 7.9 years (1997-2011)
- 54 incident cancers, excluding thyroid identified
- Standardized incidence ratios showed no significant increase in solid non-thyroid tumors, lymphoma, or leukemia in the cohort, compared with sex, age, and calendar-time-specific national rates
- Authors caution that study subjects are still relatively young for radiation-related solid tumors

Ostroumova 2016 Environ Res 147, 44-49
Deposition of cesium-137 in Belarus

Highest ground deposition of radioactive cesium occurred in Gomel oblast.

Average effective whole body doses of 10 mSv from 1986 to 2005.

Ostroumova 2016 Environ Res 147, 44-49
Key findings of 3 studies of children exposed in utero to radiation from Chernobyl

- Disorganized EEG
- Increased emotional disorders
- Increased speech-language disorders
- Decreased IQ
- Increased cases of borderline IQ (70-79)
- Important role of social-psychological and social-cultural factors

Loganovskaja 1999 Int J Psychophysiolog 34, 213-224
Kolominsky 1999 J Child Psychol Psychiary 40, 299-305
Igumnov 2000 Eur Psychiatry 15, 244-253
Fukushima, 2011 and Children

Now and the Future
11 March 2011 - Fukushima I NPP hit by tsunami
15 March 2011 - 97% of the 76,000 people living within a 20 km radius were evacuated
800 patients from hospitals and nursing homes were evacuated without medical care, water or food. At least 50 died during transport
6 hospitals designated as primary radiation emergency hospitals closed or failed to function
31 March 2013 of the 460,000 people displaced to about 2400 shelters, 2688 died due to poor medical access or illnesses arising from poor living environments
Impact of Fukushima

- Extraordinary damage, morbidity and mortality, exclusive of radiation:
  - Earthquake of magnitude 9.2 followed by enormous tsunami 40 m above sea level
  - 19,000 dead or missing, 6000 injured
  - Only 6.5% of these children or adolescents
  - 88,000 residents evacuated within 20 km of power plant

Yonekura 2013 Pediatr Surg Int 29, 1047-1051
Radiation doses received by Fukushima workers as of 2012

<table>
<thead>
<tr>
<th>Cumulative dose</th>
<th>TEPCO</th>
<th>Contractors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 250 mSv</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>200 - 250 mSv</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>150 - 200 mSv</td>
<td>22</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>100 - 150 mSv</td>
<td>117</td>
<td>17</td>
<td>134</td>
</tr>
<tr>
<td>50 - 100 mSv</td>
<td>409</td>
<td>347</td>
<td>756</td>
</tr>
<tr>
<td>20 - 50 mSv</td>
<td>646</td>
<td>2,078</td>
<td>2,724</td>
</tr>
<tr>
<td>10 - 20 mSv</td>
<td>494</td>
<td>2,667</td>
<td>3,161</td>
</tr>
<tr>
<td>&lt; 10 mSv</td>
<td>1,645</td>
<td>11,662</td>
<td>13,307</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3,340</td>
<td>16,775</td>
<td>20,115</td>
</tr>
<tr>
<td><strong>Maximum (mSv)</strong></td>
<td>678.80</td>
<td>238.42</td>
<td>678.80</td>
</tr>
<tr>
<td><strong>Mean (mSv)</strong></td>
<td>24.72</td>
<td>9.35</td>
<td>11.90</td>
</tr>
</tbody>
</table>

ISRN.fr report IRSN/DG/2012-003
Fukushima – Measured exposures

- Fukushima I NPP hit by tsunami
  - Gamma radiation exceeding 100 μSv/h in city 60 km away on 16-17 March. French nuclear safety agency estimates first year dose of 5-10 mSv of Cs-137 and 134.
  - Unlike Chernobyl, contaminated milk not a major source, as parents avoided local food & water
  - Thyroids of 1149 children examined 28-30 March. Max dose rate 0.07 μSv/h, max dose 35 mSv

ISRN.fr report IRSN/DG/2012-003
Estimated 1 yr cumulative radiation doses

- Cumulative doses predicted during the first year after the accident from exposure to radioactive deposits.
- In the area 20 to 30 km northwest of Fukushima, estimated doses reach 100 mSv, roughly equivalent to 10 abdominal CT scans per year.
- IRSN estimates that outside the 20 km zone, 70,000 people were likely to receive a dose greater than 10 mSv in the first year.

ISRN.fr report IRSN/DG/2012-003
According to the simulation, effective doses potentially received were:

- 10 mSv up to 40 km to the south
- 50 mSv inside a 20 km radius
- 50 mSv effective thyroid dose as far as 60 km to the south of the power plant related to the release from Reactor 2.
Japanese health authorities epidemiological studies:

- Basic survey of all persons present Fukushima prefecture during the release: 2,057,053 people
- Thyroid screening of all children under age of 18 during the release: 360,000 children
- Monitoring for genetic or congenital abnormalities for women who declared the pregnancy between August 1, 2010 and July 31, 2011: 6,900 women and all the children born of mothers recruited into the Japanese Environment and Children's study until age 12
- Special checkups of those most exposed: 210,000 people
As of 2014, more than 280,000 children were screened for thyroid cancer
90 cases of thyroid cancer identified (incidence rate of 313 cases per million)
Although dose of radiation was approximately 1/10 of Chernobyl, incidence of thyroid cancer appears to be much higher

Nagataki 2014 Curr Opin Endocrinol 21, 384-393
LNT= Linear No-Threshold Model

“The failure of LNT lies in the neglect of carcinogenesis and these biological mechanisms. Obstinate application of LNT continues to cause tremendous human, social, and economic losses. The 60-year-old LNT must be rejected to establish a new scientific knowledge-based system.”

Sutou 2015 Yakugaku Zasshi 135, 1197-1211
Extraordinary damage, morbidity and mortality, exclusive of radiation:

- Earthquake of magnitude 9.2 followed by enormous tsunami 40 m above sea level
- 19,000 dead or missing, 6000 injured
- Only 6.5% of these children or adolescents
- 88,000 residents evacuated within 20 km of power plant

Yonekura 2013 Pediatr Surg Int 29, 1047-1051
Radiological Emergency Response & Resources
Protective Principles

3 BASIC PRINCIPLES IN RADIATION PROTECTION

TIME

DISTANCE

SHIELDING

http://emergency.cdc.gov/radiation/
Exposure Assessment: Power Plant Release

All potentially exposed

Ask information about hours spent indoors and outdoors (where)

Means of transportation

Consumption of local water and locally grown foods

Akiba 2012 J Radiol Protect 32, 1-10
Exposure Assessment: Power Plant Release

Those extremely close to plant

The 3P's: Did you puke, poop, or pass out in 1st hour? These are extremely unlikely in this type of radiologic exposure (except plant workers & 1st responders), but indicate likely lethal doses of gamma radiation

Obtain blood for complete blood count and platelet count. Repeat every six hours for 24 to 48 hours, looking for a significant drop in absolute lymphocyte count

AHLS for Radiological Emergencies & Terrorism, University of Arizona
Types of Effects of Radiation

- **Deterministic**
  - Dose-related with a threshold
  - Typically acute or subacute
  - Examples: Acute radiation syndrome

- **Stochastic**
  - Increasing risk with increase in dose
  - Random and typically chronic
  - No threshold (?)
  - Example: Cancers, birth defects
Acute Radiation Syndrome (ARS)

- 3 syndromes, dose-dependent
  - Hematopoietic syndrome: 1-2 Gy (100-200 rem)
  - Gastrointestinal syndrome: 4-6 Gy (400-600 rem)
  - Neurovascular syndrome: >12 Gy (1200 rem)
Medical Countermeasures

Potassium Iodide: Protects thyroid from absorption of radioactive iodine.

Prussian Blue: Helps excrete radioactive cesium and thallium.

DTPA: Helps remove radioactive plutonium, americium and curium.
**Medical Countermeasures**

### Potassium iodide
- Indication: Internal contamination with radioactive I-131
  - Adults > 40y: 130 mg/d
  - Adults 18-40y: 130 mg/d
  - Pregnant/lactating: 130 mg/d
  - Adolescents > 70kg: 130 mg/d
  - Children 3-18y: 65 mg/d
  - Infant 1m to Child 3y: 32.5 mg/d
  - Neonates to 1m: 16 mg/d
- Decision to treat based on projected radiation dose to thyroid:
- Seek professional assistance

### Prussian blue
- Indication: Internal contamination with radioactive Cs
  - Adults/adolescents: 1-3g three times daily
  - Children 2-12 y: 1g three times daily
- Minimum 30d course
- Whole body counts to assess efficacy
# Radiological Emergency Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>URL</th>
<th>Telephone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poison Control Centers</td>
<td><a href="http://www.aapcc.org">http://www.aapcc.org</a></td>
<td>+1 800-222-1222</td>
</tr>
<tr>
<td>MRAT—Medical Radiobiology Advisory Team</td>
<td><a href="https://www.usuhs.edu/afrr/medicalradiobiologyadvisoryteam">https://www.usuhs.edu/afrr/medicalradiobiologyadvisoryteam</a></td>
<td>NA</td>
</tr>
<tr>
<td>AFRRI Publications</td>
<td><a href="https://www.usuhs.edu/afrr/productsandpublications">https://www.usuhs.edu/afrr/productsandpublications</a></td>
<td>NA</td>
</tr>
</tbody>
</table>
Summary

- Major nuclear accidents at power plants are Fortunately rare
- In spite of previous catastrophes, preparation for nuclear accidents is inadequate and responses deplorable
- The impact of such accidents on human civilian populations, on animals, and the environment in general are enormous and long-lasting
- Greener energy resources (solar, wind, geothermal) do not pose the risks to children and the environment posed by nuclear energy and are now feasible on a large scale in some areas
Available on Request
Webinars
Series of scientific webinars that provide a forum for discourse on scientific issues.
Live and On-Demand
Case Conferences
Journal Clubs
Grand Rounds
CE Available

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Evidence-based online courses on a variety of children's environmental health topics.
Interactive and Self-Paced
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